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Raw Materials

The United States uranium production increased 30.0 percent in 1959 over 1958, and this country was in first place among free world uranium producing countries. Domestic production of uranium plus imports of concentrates continued at levels adequate to meet current requirements.

This was a year of increasing stability for the domestic industry as the Atomic Energy Commission moved forward with its announced program of contracting for purchase of domestic uranium concentrates through 1966. As a result of the discovery in recent years of large, relatively high-grade uranium deposits, coupled with improved mining and milling practices, the domestic industry should be in a favorable position to compete with foreign producers when the industrial market develops.

Domestic ore production reached a total of 6.9 million dry tons during 1959, and production of uranium concentrates (U_3O_8) totaled 16,390 tons.

Private companies continued development of ore bodies at a high level during the year. Preliminary figures indicate that ore reserves increased from 82.5 million tons on December 31, 1958, to 86.0 million tons on December 31, 1959, a net increase of 3.5 million tons during a period when approximately 6.9 million tons were mined.

Uranium concentrate deliveries previously contracted for with Canada and with Combined Development Agency sources—Australia, Belgian Congo, Portugal, and South Africa—were continued at a normal rate during 1959.

The United States reserves, together with the large ore bodies already developed throughout the free world, provide sound support for a broad nuclear power program. Although further discoveries will no doubt be made, exploration activity is expected to be governed largely by the progress made toward competitive nuclear power.

Domestic Activities

12-Year Record of Procurement

The Commission published in September the statistics on U.S. uranium concentrate procurement from domestic and foreign sources

for the 12 fiscal years 1948–59, and a combined total for the years 1943 through 1947. This action followed the Commission's declassification of all data on uranium ore and concentrate production and procurement before July 1, 1955. Statistics subsequent to that date were declassified in 1956. Procurement statistics in tons of concentrates are as follows:

Fiscal years	*Domestic (tons)*	*Foreign (tons)*	*Total (tons U_3O_8)*
1943–47 inclusive	1, 440	10, 150	11, 590
1948	110	1, 960	2, 070
1949	120	1, 960	2, 080
1950	320	2, 740	3, 060
1951	630	3, 050	3, 680
1952	830	2, 830	3, 660
1953	990	1, 910	2, 900
1954	1, 450	3, 240	4, 690
1955	2, 140	3, 800	5, 940
1956	4, 200	6, 240	10, 440
1957	7,580	8, 580	16, 160
1958	10, 244	16, 132	26, 376
1959	15, 162	18, 164	33, 326

Receipts of uranium concentrates from domestic sources, which in fiscal year 1959 constituted about 45 percent of the total procurement are expected to exceed those from foreign sources in fiscal year 1961.

Ore Reserves

Preliminary estimates indicate that reserves of uranium ore as of December 31, 1959, were approximately 86.0 million tons containing 0.28 percent U_3O_8. This is an increase of 3.5 million tons over the estimate at the end of 1958. In addition, there were approximately 1.3 million tons of ore in Government and private stockpiles at the end of the year. Final year-end reserve figures by States will be released in March 1960 in the Commission's semiannual announcement of "Domestic Uranium Production Statistics for Last Half of 1959."

Modification of Purchase Program

On November 24, 1958, the Commission announced a modification of the 1962–66 domestic uranium concentrate procurement program,[1]

[1] See p. 8, Twenty-fifth Semiannual Report to Congress (July–Dec. 1958).

remainder is eliminated principally in exhaled air. The fraction re-utilized varies from person to person; but is comparatively constant for each individual. Some of this carbon dioxide is used by the body to synthesize other chemicals, and the majority is in some sort of equilibrium with the carbonate portion of bone. Information on the fraction of CO_2 that is recycled provides a correction factor which is applied to data on the oxidation of a substance such as glucose, so that variations in the percent of dose recovered as $C^{14}O_2$ can be adjusted accordingly.

The Argonne group is studying various aspects of glucose metabolism in healthy subjects, and in patients with diabetes, cancer, and drug-induced hemolytic anemia. Variations in the rate of oxidation of each of these carbon positions are being evaluated in an attempt to develop better methods to study disease states in man.

Fallout Studies

Beginning with the first test in 1945, the United States has conducted 16 series of weapons tests. This country announced the first nuclear detonation by the Union of Soviet Socialist Republics in 1949, and the United Kingdom initiated its series of weapons tests in 1952 (see Appendix 15 for list).

With the exception of the first test during the war, the United States has announced each series publicly in advance. Before being authorized, each shot fired by this country was evaluated individually for its contribution to the advancement of nuclear weapons technology, or to important gains in knowledge about weapons effects. A major associated effort in United States tests has been to obtain information for the protection of the civilian population in event of nuclear warfare.

Approximately 20 percent of the United States detonations have been of high-yield thermonuclear designs and 80 percent of fission devices. The first test—TRINITY at Alamogordo, N. Mex., July 16, 1945—demonstrated the feasibility of an atomic weapon. In July 1946, two devices were fired in Operation CROSSROADS at Bikini Atoll in the Pacific Ocean for information on the effects on ships of atomic bursts. Subsequent United States tests were:

- Operation SANDSTONE, spring of 1948, Eniwetok Proving Ground EPG).
- Operation RANGER, early 1951, Nevada Test Site (NTS).
- Operation GREENHOUSE, spring of 1951 (EPG).
- Operation BUSTER-JANGLE, fall of 1951 (NTS).
- Operation TUMBLER-SNAPPER, spring of 1952 (NTS).

Operation IVY, fall of 1952 (EPG).
Operation UPSHOT-KNOTHOLE, spring of 1953 (NTS).
Operation CASTLE, spring of 1954 (EPG).
Operation TEAPOT and WIGWAM, spring of 1955, NTS and off the coast of California.
Operation REDWING, summer of 1956 (EPG).
Operation PLUMBOB, summer of 1957 (NTS).
Operation HARDTACK, summer and fall of 1958 (EPG and NTS).
Operation ARGUS, fall of 1958, South Atlantic.

Radioactive fallout from detonation of nuclear weapons has been identified since the first test explosion. Its importance increased with the greater number of devices set off, and with the advent of thermonuclear explosions—the first was fired in Operation *Ivy*, 1952—since these fusion devices hurled debris into the upper regions of the atmosphere and this has resulted in more widespread distribution of fallout. Strontium 90, one of the more troublesome fallout products because of its long continued radioactivity and its assimilation in food chains where it competes with calcium, is a product of atomic fission, but not of fusion.

Studies of the distribution and possible effects of radioactive fallout began with the first nuclear detonation in 1945. Initially, this work was limited to relatively high-intensity radioactive areas near detonation sites. Wind drift of radioactivity from test detonations was traced regularly by plane until the clouds dispersed, and readings were taken in and near the test sites. As the problem increased, monitoring stations were set up, and programs of sampling and analysis undertaken. The Commission has engaged continuously in studies of the biological effects of all important types of radiation, as did the wartime operator of Federal atomic energy activities, the Manhattan Engineering District, Corps of Engineers, U.S. Army. The results of this broad work on radiation effects and radiation protection, like the results of fallout studies, have been reported regularly and fully to the public and the Congress. This report, in another section, describes the progress of research related to these problems.

On fallout and its possible consequences, the Commission constantly makes new information available as rapidly as possible. Information on some aspects of fallout necessarily is held in secret since they bear directly on security and national safety. Decisions in this field are not made by the Commission alone, but in concert with the Department of State, the Department of Defense, and the Central Intelligence Agency. This special section of the Annual Report to Congress for 1959 reviews the history, and current status, of the fallout studies.

Chronology of Fallout Studies

The Commission's studies on fallout were initiated in 1947 through a small group from the University of California at Los Angeles. Beginning with a reconnaissance radiological survey of soil, animals, and vegetation at the *Trinity* (1945) detonation site near Alamogordo, N. Mex., this program had developed into an extensive research program by the time of the 1951 Nevada test series. These studies help delineate fallout patterns up to several hundred miles from a test site, determine soil-plant-animal relationship in uptake of weapons debris, and characterize various types of fallout material. Air, soil, plant, and animal samples are obtained and analyzed for a number of radionuclides under this program. Results of surveys made following the latest Nevada test series are given in Appendix 16.

The Naval Research Laboratory began an air sampling program for natural radioactivity measurements in 1948. Measurements of fission product radioactivity were begun in 1950. Daily air samples are collected at 21 stations along the 80th Western Meridian from Thule, Greenland, to Punta Arenas, Chile. Gross radioactivity measurements and radiochemical analyses of a number of radionuclides are made. This work is now a part of the Commission fallout monitoring program.

In 1951, rain samples taken in the northeastern United States and analyzed by the Commission indicated traces of fallout material from Nevada tests earlier that year. A sample collection network was established for subsequent tests at Eniwetok Proving Ground that year, and a nation-wide monitoring system was established under the direction of the Commission's Health and Safety Laboratory in New York.

During the spring 1952 Nevada test series, two-man mobile monitoring teams made measurements of external gamma radiation and airborne radioactivity at widely distributed locations within 200 to 500 miles of the Nevada Test Site. Gummed-film and air samples also were collected at 121 fixed monitoring stations set up with the United States Weather Bureau, Department of Commerce. Samples were analyzed for gross radioactivity, and later estimates were made of strontium 90 deposition. Other Federal and State agencies and private organizations assisted in making collections and analyses.

In October 1952, the network using gummed-film collectors was expanded to include a number of stations outside continental United States. Other foreign stations were added in February 1954, and an expanded monitoring network operated during the Nevada test series

of that year. This program continued through the test series conducted during 1958.

Two networks of air and external radiation monitoring stations were established prior to the 1957 Nevada test series. One comprised Commission installations—national laboratories and major research contractor sites where background radiation is measured routinely; the other was established in cooperation with the Commission during 1956 by the United States Public Health Service, Department of Health, Education, and Welfare. Both networks analyzed air samples for gross beta radioactivity and obtained on a daily basis measurements of total beta-gamma background activity. This network also has measured radioactivity in rainfall continuously since before the 1957 Nevada test series.

In 1953, after the Commission engaged the Rand Corp., to study the fallout problem, a review conference was held which led to the present program of worldwide fallout studies.

An extensive program of research to study the mechanisms involved in worldwide fallout was initiated in 1954 by the Commission through its Health and Safety Laboratory, and through the University of Chicago and Lamont Geological Observatory of Columbia University. These have collected and analyzed for radioactivity, particularly for strontium 90, samples of soils, air, water, milk and other foods, and animal and human tissues. Later the Department of Agriculture entered this program and, in 1955, initiated a program to determine levels of strontium 90 in soils on a worldwide basis. Other more limited sampling programs also were initiated. The Commission currently is assisting in training personnel of the Food and Drug Administration, Department of Health, Education, and Welfare, in the radiochemistry involved in such analyses. The current FDA program includes analyses of food samples for gross radioactivity.

Precipitation fallout collections at 13 stations in the United States and at 17 stations outside this country were begun in early 1954. Analyses of fallout samples, collected in stainless-steel pots, were made for strontium 90. Work was initiated in 1956 for sampling and strontium 90 analyses of precipitation at Mount Washington Observatory, New Hampshire. Stations were established at Pittsburgh, Pa., in 1955 and at Westwood, N.J., in 1958 to obtain precipitation samples which are analyzed for strontium 90, barium 140 and tungsten 185. This program was expanded in 1959 using an improved collecting method (a plastic funnel and an ion-exchange column). Samples also are obtained in the Atlantic Ocean aboard Coast Guard ships.

The Commission's high-altitude sampling program for fission product radioactivity began in 1956, using balloon-borne sampling devices

Zone. Samples were obtained at nominal 50,000,- 65,000,- 80,000- and 90,000-foot altitudes and analyzed for several radionuclides. The program since has been reduced to two sampling locations at Sioux City, Iowa, and San Angelo, Tex.

In 1956, the Los Alamos Scientific Laboratory began a program to measure radioactivity, especially cesium 137 and natural potassium 40 in milk and in man. Measurements have been made with a large scintillation whole-body counter. Measurements have been made of people from all over the world visiting Los Alamos.

In addition to the various sampling programs, many research activities are performed under the auspices of the Commission which contribute to basic knowledge of fallout and its effects in the overall fallout studies program. While most of these activities are described elsewhere in this report, a few of them are included in a later part of this section.

Standards for Radiation Protection

In evaluating the risk from fallout, the standards commonly used are largely based upon the recommendations of such groups as the National Committee on Radiation Protection and Measurements, the International Commission on Radiological Protection, the National Academy of Sciences, and the Medical Research Council of the United Kingdom. Some of these recommendations relate directly to questions of hazards from fallout; others may provide useful guidance. These standards generally are applied through establishing exposure levels designated by such terms as "maximum permissible dose" and "maximum permissible concentration." Maximum permissible exposures set for occupational activities, for individual members of the public, and for the general public, are neither absolutely safe nor dangerous. In the judgment of those making the recommendations, it is an exposure which represents the greatest hazard that, in their opinion, should be permitted under the conditions to which the recommendation is applicable. Under different conditions, either a lower or a higher permissible dose might be recommended.

The Federal Radiation Council, established by executive order of the President and by statute, September 23, 1959, has the responsibility for recommending to the President, among other standards, those which it judges should apply to environmental exposures from all sources.

Recommended values of maximum permissible doses of radiation generally involve the assumption that the hazard of some radiation

the exposure stipulated as the recommended maximum permissible dose would mean increasing the hazard involved to twice the level which the recommenders considered justifiable under the conditions for which the recommendation was made. How great a hazard this may be depends, of course, upon estimates of the hazard that would result from the recommended maximum permissible dose. Hence, a recommended maximum permissible dose has no specific significance except that it marks the point at which an advisory group has agreed to draw the line in recommending the maximum degree of hazard that is appropriate under a given set of circumstances.

There is a sharp difference between permissible doses of radiation to persons and the maximum permissible concentrations of radioactivity in the environment.

The radiation dose actually received by persons is being measured. The best information on the uptake by humans of radioactivity from fallout in the environment is that being obtained by examinations of small children most nearly in equilibrium with the radiation in their environment. Measurements of this kind will assist in developing, within the next few years, realistic values for the maximum concentrations of radioisotopes resulting from fallout that should be permitted in the total food supply. Present standards for concentration have been determined on the basis of the best information and recommendations available, with the addition of a large safety factor.

In principle, establishing the best possible value for a maximum permissible exposure involves at least three independent evaluations: (*a*) estimating the total biological risk, (*b*) estimating the benefits to be gained from taking the risk, and (*c*) balancing the risk against the reason for taking the risk.

The uncertainties involved in estimating the biological risk are indicated in the research currently being carried on, as described elsewhere in this report. The uncertainties involved in estimating the benefits to be gained by taking the risk probably are much larger. The most difficult step is that of comparing biological risk to benefits which may be measured in economic or social gains, considering also that some or all of the benefits may not accrue to the person taking the risk.

In occupational standards, one criterion commonly used is that risks due to exposure to radiation should be small compared to other occupational risks. How small would depend upon the comparative ease of avoiding the risks, and the reasons for accepting a risk of any particular magnitude, which reasons are to be found in the difficulties—in the form of time, personal inconvenience, expense, or other reason—involved in avoiding the risk.

primary benefits to be derived from the activity in which the risk arises. These primary benefits may be sufficiently large to outweigh by far any risks involved, although it still may be desirable to reduce the risk by various possible means.

Standards of radiation protection, while based upon logical concepts, never can be ideal. This is not a condemnation of the standards nor of the system by which they are formulated, but rather a recognition that imperfections and compromises are inherent in most solutions to complex problems. In environmental health, radiation protection shares this difficulty with all other health standards.

Fallout Radiation Levels

Recent measurements of radioactive fallout in the soil, rainwater, surface air, upper air, milk and food under Commission and cooperative programs are summarized in this section.

Strontium 90 in Soils

Measurement of strontium 90 levels in soil sampled at 77 locations throughout the world, made by the Commission's Health and Safety Laboratory working with the Department of Agriculture, provide a good indication of current strontium 90 deposition. They help in estimating present and future levels of this radioactivity in man. Radioactivity levels in soil provide an indication of changes in the amount of strontium 90 which has fallen out, and the availability of this radioisotope for uptake in food plants and eventually in human bone. Of the total strontium 90 in soil at any time, only a small fraction will eventually reach human bone. On the other hand, some strontium 90 enters food crops and fodder directly from the air and rain without first entering the soil.

The following table gives total strontium 90 levels in soils as collected in October 1958. Soil samples usually are taken at several depths down to 6 inches, or, in some cases, 12 inches.

Location	*Sr 90 millicuries per square mile*	*Location*	*Sr 90 millicuries per square mile*
Albuquerque, N. Mex	27	Memphis, Tenn	37
Atlanta, Ga	37	New Orleans, La	34
Binghamton, N.Y	40	New York, N.Y	37
Boise, Idaho	38	Philadelphia, Pa	44
Des Moines, Iowa	56	Rapid City, S. Dak	74
Detroit, Mich	40	Rochester, N.Y	33
Grand Junction, Colo	39	Salt Lake City, Utah	78
Jacksonville, Fla	36	Seattle, Wash	30

The average level of strontium 90 in soils collected in October 1958 in the United States between latitudes 40° and 50° North was 46.9 millicuries per square mile (mc/mi ^{2}), while the average between 30° and 40° North was 32.6 mc/mi^2. The levels in the United States appear to be 10 to 15 mc/mi^2 higher than the world average because of tropospheric fallout from weapons tests and higher rainfall rates, except that, west of the Rocky Mountains, levels are about the same as the world average. This may be due to lower levels of rainfall. Analysis of 1959 soil samples has not been completed. Data already collected indicate substantial increases over 1958 levels of strontium 90.

Fission product radioactivity analyses in monthly soil samples, using gamma ray spectroscopy, were continued at Argonne National Laboratory during 1959. Analyses for the gamma emitters include zirconium 95, niobium 95, cesium 137 and 144, ruthenium 103, and cerium 141. Monthly total levels in the spring of 1959 of 4,000 to 5,000 millicuries per square mile were remarkably consistent for a period when the fallout was relatively heavy. Individual radionuclides showed peak activities at various times, depending on half-lives, from March to July.

Monthly Fallout Collections

Monthly fallout collections are made through the worldwide network of stations [44] set up by the Commission and analyses are made for strontium 90, strontium 89 and tungsten 185. These data provide information concerning the rate of fallout and its accumulation. During the United States' tests at the Eniwetok Proving Ground in 1958, tungsten produced in some devices provided a tracer material for fallout collection studies. Tungsten was partially transformed into radioactive tungsten 185 (74-day half-life) which provided additional information on the world-wide fallout pattern from equatorial tests.

The monthly data during late 1959 indicate a decrease in the rate of fallout in the United States after generally rising rates from January to May. The highest rates generally appeared to occur during February and March on the west coast and Hawaii, and in April and May on the east coast with a range between these for other areas,

[44] Includes 35 steel pot and ion-exchange stations and 3 precipitation stations in the United States, 4 Coast Guard (ship) rain collecting stations in the Atlantic, and 28 steel pot and ion-exchange stations in 14 foreign countries.

reaching 6 millicuries of strontium 90 per square mile per month in some places. Monthly fallout rates during 1959 in the United States have been higher than during 1958, but since mid-year have decreased to much lower levels. It is expected that the rate of fallout from past tests generally will decrease further in subsequent years, although temporary seasonal increases would, on some hypotheses, be expected.

Surface Air Monitoring

The surface air monitoring networks indicated generally rising levels of gross radioactivity in the atmosphere during the early months of 1959, a continuation of the rising levels noted in November and December of 1958. The levels reached their highest in the spring of 1959 and decreased to one-half to one-third of the peak values by June and July. The levels in the Southern Hemisphere were 50 to 100 times lower than those in the United States. Levels in Alaska and Hawaii also were lower than in continental United States.

Stratospheric Monitoring

High-altitude air sampling was continued at Sioux City, Iowa, and San Angelo, Tex., during 1959. The Sioux City Station ceased sampling late in the year. Sampling at Sao Paulo, Brazil, was discontinued in February. At each site sampling was carried out between 50,000 and 90,000 feet altitude. Samples also were obtained from Denver, Colo., at altitudes greater than 90,000 feet. Some balloon-borne sampling research flights were made at Minneapolis, Minn., by General Mills, Inc. and Chicago Midway Laboratory.

High altitude samples are analyzed for barium 140, zirconium 95, cerium 144, cesium 137, strontium 89, strontium 90, and tungsten 185. These data are of value in studying meteorological and fallout phenomena, especially in material balance studies.

Studies of Uptake in Foods

The Commission's Health and Safety Laboratory continued to obtain milk samples for strontium 90 analyses at Mandan, N. Dak. and Perry and New York, N.Y. Levels in milk for the first 9 months

at these locations, micromicrocuries per gram of calcium, were as follows:

Sampling month	New York, N.Y. (liquid milk)	Perry, N.Y. (powdered milk)	Mandan, N. Dak. (powdered buttermilk)
January	8.2	8.1	20.8
February	8.4	7.6	18.4
March	8.1	6.6	23.9
April	7.7	7.2	27.8
May	13.4	8.9	47.5
June	26.2	8.9	37.9
July	14.4	7.0	22.2
August	10.7	7.8	24.0
September	9.8	6.1	16.6

The June sample from New York City, reported as 26.2 micromicrocuries per gram of calcium, was higher than any previously reported for that station. The value for New York City liquid milk reported by the Public Health Service for June was 14.0 micromicrocuries per liter, very nearly equal to 14 micromicrocuries per gram of calcium. This difference is possibly due to the difference in source of the two samples. The Health and Safety Laboratory sample for New York City dropped to 9.8 micromicrocuries per gram of calcium in September, about half the June value. The May sample for Mandan is the highest value reported for milk in the United States, as far as Commission records show. By September, however, the level had dropped to 16.6.

Samples of wheat harvested in 10 Minnesota areas from 1956 to 1958 were provided by the University of Minnesota for analysis by the Health and Safety Laboratory and the analyses for strontium 90 were completed in early 1959. Strontium 90 levels ranged from 17 to 76 micromicrocuries per kilogram in 1956, 47 to 112 in 1957, and 35 to 60 in 1958. Similar samples of 1958 wheat from the major wheat-producing states also were furnished by the University of Minnesota, the levels ranging from 21 to 133 micromicrocuries of strontium 90 per kilogram. North Dakota wheat samples from the August, 1958, crop furnished by the North Dakota Agricultural College and the United States Department of Agriculture's Mandan Agricultural Experiment Station contained 29 to 54 micromicrocuries of strontium 90 per kilogram. Minnesota seed corn yearly samples for the years 1945 to 1958 indicated levels too low to be quantitatively detected.

Data for strontium 90 in flour and bread samples were collected in New York City during February and May 1959. The May data indicate that strontium 90 levels in two samples of whole wheat bread (37 to 59 micromicrocuries per kilogram) were about five times the levels in two white bread samples (12 micromicrocuries per kilogram)

flour was 189, compared to 12.8 in a sample of white flour. The values for the white bread sampled in May are somewhat higher than the February figures; however, the values for the whole wheat bread sampled in May are considerably lower than the February values. The levels in the flour samples in May differed little from those sampled in February. Samples of whole wheat bread collected in June, July, and August showed 29, 27, and 52 micromicrocuries per kilogram while white bread showed about the same value as for May.

As has been previously reported,[45] the relationships between strontium 90 levels in foods and maximum permissible dosage involve the entire diet over a matter of many months. The significance of concentrations in single items of food, such as whole wheat bread, depends upon the extent to which these contribute to the total diet.

Other uptake studies of radioactivity involved analyses of other foods, human bone, soils, and animals. Human bone samples from the New York City area analyzed by the Lamont Geological Observatory showed levels of 0.53 to 2.62 micromicrocuries of strontium 90 per gram of calcium for children (fetus to 11 years) and 0.43 to 1.19 for adults.

Investigators at the University of Nevada, under contract with the Commission, and the Nevada Test Organization have reported strontium 90 levels in milk and bones of cattle collected in Nevada during 1958. Nevada samples were collected at Knoll Creek, and Delamar Valley in the Southeastern part of the State, and the Nevada Test Site. Cattle bone levels at these locations ranged from 3.7 (rib) to 44.8 (femur) micromicrocuries of strontium 90 per gram of calcium, both extremes were from the Nevada Test Site samples. Milk levels determined in Knoll Creek and Delamar Valley samples in May and November, 1958, showed a value for May at Knoll Creek of 5 micromicrocuries of strontium 90 per gram of calcium to be the highest. Studies conducted in other areas of the United States have suggested that human bones accumulate less strontium 90 than animal bones under the same exposure conditions. The Nevada milk and bone data also suggest that values to be expected in persons living in that State would be well below the values that have been measured in cattle.

Data for cesium 137 in more than 273 people from 25 States, and in more than 1,364 samples of milk from 37 locations in 28 States, was collected for 1958 at the Los Alamos Scientific Laboratory. Because of the biochemical similarity of cesium and potassium, cesium 137 levels are conveniently expressed as micromicrocuries of cesium 137

[45] See HASL–65, John H. Harley, "Dietary Strontium 90 Estimates for the United States," Office of Technical Services, U.S. Department of Commerce, Washington 25, D.C. $3.50.

per gram of potassium. The samples of nonfat dry milk ranged from 7 to 297 micromicrocuries of cesium 137 per gram of potassium. During 1958 the average milk value was 50 such units with some samples as high as about 250. The 1959 levels in people ranged from 12 to 170 units. The 1958 average for the United States was 67 units.

Research Findings on Fallout

Pattern of Distribution of Radioactive Fallout

Measurements of fallout on the ground and of radioactivity in the troposphere and stratosphere have made apparent some of the complexities of the true patterns of global transport and mixing, as contrasted with idealized models. Knowledge about the distribution of weapons debris in the atmosphere has been greatly improved by data from Department of Defense programs, augmented by Commission stratospheric balloon data for the upper atmosphere and by other Commission data for air, water and soil at the earth's surface.

Commission and Department of Defense upper atmosphere data have demonstrated in the tropical latitudes a well-defined drop in atmospheric radionuclide concentration from the stratosphere into the troposphere. These data also suggest strongly the lack of any prompt uniform mixing in the stratosphere, either horizontally from pole to pole or vertically. Reliability of the balloon data, while improving, is not yet sufficient to warrant their use alone with any great assurance, but as a supplement to Department of Defense data they are valuable and confirmatory.

One important prediction has been verified: A substantial reservoir of longer lived fission products does exist in the stratosphere. The exact inventory still is in some doubt. Various estimates based on measurements just before the Soviet Union October test series in 1958 ranged from 600,000 to about 1,800,000 curies of strontium 90.

The information available about debris thrown into the stratosphere is subject to large uncertainty. In addition to knowledge of the total and fission energy yields of all weapon explosions it would be necessary to know whether they were land, water or air bursts. Even then it is difficult to estimate the fractions of the debris produced that come out as local fallout relatively near the site of detonation, tropospheric fallout, and stratospheric fallout. This information is obtainable only from actual measurement taken on some United States shots at the time of testing. These measurements may or may not be applicable to other shots under differing test conditions. Ta-

bles of yields of nuclear weapons detonated during tests are included in Appendix 15.

Estimates of stratospheric inventory based on measurements in the stratosphere can be combined with other information such as input rates and fallout rates to provide estimates of the length of time various radioactive materials may remain in the stratosphere. Predictions of the consequences of testing or of nuclear war depends in large part upon what can be determined about this residence time in the stratosphere.

The concept of stratospheric residence time as being a single figure applicable to all stratospheric debris has been modified. The first large injections of debris in 1952 and 1954 were placed high in the equatorial stratosphere. Vertical exchange of air is especially slow in these latitudes because of the intensity of the stratospheric temperature inversion, and because seasonal rearrangements of the atmospheric circulation are at a minimum. Many subsequent high-yield tests have not placed debris so high in the stratosphere.

During 1958, a number of tests were made by the Soviet Union north of the Arctic Circle. There, vertical mixing and entry into the lower atmosphere are more rapid, particularly in winter and early spring. In the polar regions, the stratosphere's altitude also is much lower than in the tropics. In the middle-latitudes so-called "double tropopauses" occur, where the higher tropical stratosphere overlaps the lower polar stratosphere. These overlaps, or breaks, are thought to provide an opportunity for horizontal movements of air out of the stratosphere.

These variabilities in stratospheric conditions complicate estimates of strontium 90 inventories and rates of deposition. Regardless of the actual pattern or residence time of debris in the stratosphere, it is clear that the debris does not fall out uniformly on the earth's surface. Strongly defined North-South irregularities exist.

For purposes of predicting and estimating hazards, the observed North-South fallout patterns must be separated into components representing stratospheric and tropospheric fallout. Since some weapons have been fired which yielded only tropospheric debris, it should be easier, in principle, to study these shots and arrive at an understanding about tropospheric debris patterns. Assuming an estimate of the location and amount of world-wide tropospheric fallout, subtracting this from the total should indicate the location and amount of stratospheric fallout.

Knowledge about the tropospheric fallout from small shots is limited however, and the applicability of this knowledge to tropospheric fallout from large yield shots is even more limited. Tropospheric

fallout is to be thought of in terms of masses of debris distributed vertically and horizontally in the lower atmosphere (where the weather is), and presumably subject to spreading and mixing, and wanderings as buffeted by winds. Tropospheric fallout does not descend in an even band about the earth. Weather trajectories of debris from both Pacific and Nevada shots strongly support this interpretation. Actually, tropospheric winds at the Eniwetok Proving Ground tend to blow in nearly opposite directions at different altitudes.

In different places different amounts and rates of fallout are found reflecting the global variations in stratospheric and tropospheric transfer, and the variations in location of tropospheric debris. Good evidence indicates that debris introduced into the upper stratosphere just north of the equator at about 10°N has a mean residence time in the stratosphere of several years, and perhaps as much as one-third of it will descend in the Southern Hemisphere. If introduced in the lower stratosphere at the same latitude, the debris' mean residence time will be not more than two or three years.

If the debris is introduced in the North Temperate Zone or farther north the mean residence time appears to be of the order of a year or less with very little mixing across the equator. In either hemisphere the debris appears to be falling out preferentially between 30° to 60° latitude, regardless of the latitude of injection. Relatively little fallout occurs near either pole or the equator. This phenomenon seems to be related to preferential leakage through the break between the high tropical tropopause and the lower polar tropopause in North and South Temperate latitudes.

Differences in the rates of fallout, and the rates of world-wide spread between equatorial and polar tests, now are appearing as the debris from Operation Hardtack of 1958 tagged with tungsten 185, and the fresh debris from the Soviet Union series of October 1958, are being sampled and measured.

Weather also is a factor in determining places where debris may fall out. Local inequalities in fallout are in great part determined by rain, the chief vehicle for its deposition. This holds true for debris filtering down from the stratosphere.

Local conditions also may produce variability in measurement since forests do not behave like meadows nor mountain-tops like valleys as repositories of fallout. Cyclonic and orographic (mountain) rainfall will behave differently as scavengers. Soil samples cannot be expected to contain the same amounts of strontium 90 as rainwater collections or collections on gum paper.

As further experimental data are obtained some fallout puzzles

reason to expect the global atmospheric circulation to behave in a simple manner.

Discrimination Against Strontium 90

Research here and in the United Kingdom indicates that plants show no consistent discrimination against strontium 90 in the soil. No plant is known which has the remarkable capacity that some mollusks and diatoms have of being able to discriminate almost totally against strontium in favor of calcium. Strontium 90 uptake from soil can be reduced by existing methods of treatment with simple chemicals (containing, for example, calcium or potassium) by at most one-half.

Mechanisms exist also for strontium 90 and cesium 137 to enter plants either by direct uptake through the leaves, or by uptake in the grass mat through the base of the stems. British research demonstrated that the cereal grasses readily absorb soluble strontium 90 salts into the grain if the salts are sprayed on during the formative stage of the grain. These mechanisms seem to account for the fluctuation in strontium 90 content of food from month to month and year to year as seen in milk and wheat. The low points seem more likely to represent uptake from soil.

These findings do not resolve, however, the question of whether the peaks result from stratospheric or tropospheric fallout. Milk collected by the Mandan Agricultural Experiment Station reached a peak value of 33 micromicrocuries of strontium 90 per gram of calcium in the summer of 1957. A relatively heavy rainout of tropospheric fallout from United States 1957 Nevada tests probably was responsible for this peak. On the other hand, even higher levels of strontium 90 in milk observed during early 1959 must be attributed to stratospheric fallout.

Effects vs. Radiation Dose

The Commission has no new evidence clearly indicating that effect is directly proportional to dose regardless of dose rate, but no conclusive evidence has been found pointing to a true threshold below which effects do not occur. Effects versus radiation probably is best represented by a series of curves, one for each of a number of situations involving a given dose rate and dose schedule, i.e., the matter of divided doses as incurred with diagnostic X-rays as opposed to the more uniformly incurred exposures from fallout.

Data on internal emitters in humans and experimental animals

point to a sharp break in the curve representing bone tumor formation which occurs well above any recommended permissible levels. This indicates that, even though a threshold may not exist, very few bone tumors will result from low body burdens of strontium 90. The data for leukemia induced in mice from internal radiation sources are not so clear. Data on life span effects from fallout have not been clarified.

Research Programs

Somatic effects. Information still is meager on the effects of low levels of chronic radiation exposure and low total doses. The United Nations Scientific Committee on the Effects of Atomic Radiation, for example, found that after reviewing all available data, it was unable to make a categorical statement on leukemia and radiation exposure. The data indicated a threshold for radiation-induced leukemia as high as several hundred roentgens. On the other hand, the Committee estimated the number of cases of leukemia which might occur should the effect of radiation be directly proportional to radiation dose regardless of dose rate. The Committee made similar calculations for bone cancer, but at the same time noted that, whereas X-ray radiologists appear to have a higher incidence of leukemia than do nonradiologists, no corresponding increase in bone cancer has been observed. Nevertheless, the absorbed dose of radiation in bone that could be affected by tumors probably was greater than the dose to the bone-marrow which is involved in leukemia.

At hearings held on fallout before the Special Subcommittee on Radiation of the Joint Committee on Atomic Energy of the Congress May 5–8, 1959, a panel of 22 scientists was convened to attempt predictions of exposures which, in their opinion, would result from fallout from all weapons testing to date and to estimate the strontium 90 accumulation in soil and in humans. The panel estimated that in the United States the genetically significant dose from tests to date would be about 0.05 rad while the average body burden of strontium 90 would be about 6 micromicrocuries per gram of calcium. Commission staff made estimates of the possible effects of fallout to date based on an average body burden of strontium 90 of 10 micromicrocuries per gram of calcium and on a genetically significant exposure of 0.15 rads.

Figuring from the higher dose estimates, it can be estimated on the basis of one current theory that the maximum number of additional

cases of bone cancer that could occur per year in the next 70 years would be 50 to 100, and for leukemia as much as double that figure. There may be no additional cases at all, as the United Nations Scientific Committee was so careful to point out.

Genetic effects. On this same basis, genetic effects during the next 30 years would average not more than 20 persons born each year with tangible genetic defects and several times that number with lesser genetic defects, stillbirths and the like. In this country there would occur not more than 500 greater or lesser tragedies of this nature to add to the some 1,400 fatalities and a large number of serious injuries each year readily identifiable with other aspects of our defense efforts. If weapons tests that produce fallout are not resumed, these rates, if realized at all, would subside gradually with succeeding generations.

While the statement "no radiation exposure to the gonads without some genetic effect" seems to still hold, work at Oak Ridge National Laboratory and in the United Kingdom clearly demonstrates that mutations depend on the rate at which radiation exposure occurs. Whether these new data mean that the true doubling dose for man or mice—the dose of radiation that will cause the spontaneous genetic mutation rate to double—is the 40 *r* taken by the United Nations Scientific Committee or is higher remains to be resolved. Certainly the new evidence would suggest the 40 *r* figure is not too high for exposure incurred at very low dose rates.

Current Research Activities

The Commission keeps informed of the vast amount of information being developed for other purposes and has concentrated its own research efforts on completing the picture of fallout.

Some of the most valuable information the Commission has on the movement of fission products in the air or the soil and the deposition on vegetation and soil of particulate or gaseous radioactive material comes as a byproduct of operating production and processing plant sites and conducting weapons test sites.

The Commission-sponsored program of research directed specifically into the nature and hazards of fallout has grown steadily during the past 2 years. Table VI, showing a budgetary increase of nearly 130 percent in this category, outlines the extent of this research and in closely related activities.

TABLE VI.—SUMMARY OF FALLOUT RESEARCH AND RELATED ACTIVITIES

	Actual fiscal year 1958	Actual fiscal year 1959	Estimated fiscal year 1960
FALLOUT SAMPLING AND ANALYSIS	$1, 708, 573	$2, 396, 726	$3, 952, 000
PROGRAM ACTIVITIES RELATED TO THE DEVELOPMENT OF RADIATION STANDARDS	25, 155, 251	30, 263, 566	34, 832, 000
Research Related to Radiation Standards of Permissible Exposure (Radiation Biology)	15, 738, 263	18, 794, 742	21, 188, 000
Research Related to Radiation Standards Involving Environmental Contamination and Waste Disposal	2, 708, 122	3, 861, 282	5, 025, 000
Research Related to Prophylaxis and Treatment of Radiation Injury	3, 150, 623	3, 301, 844	3, 397, 000
Dosimetry and Instrumentation	2, 027, 703	2, 115, 831	2, 497, 000
Radiation Protection—Physical	867, 616	1, 138, 489	1, 205, 000
Radiation Measurements—General	662, 924	1, 051, 378	1, 520, 000
PROGRAMMATIC NOT DIRECTLY RELATED TO THE DEVELOPMENT OF RADIATION STANDARDS	8, 474, 246	9, 347, 465	10, 216, 000
Total Biology and Medicine Program	35, 338, 070	42, 007, 757	49, 000, 000

The problem of rate and pattern of transport of fallout and its final distribution over the surface of the earth is primarily meteorological. The closest possible liaison with the Weather Bureau, the Air Force and the Defense Atomic Support Agency personnel and their related studies has been essential and has been successfully achieved. The Commission has encouraged, and where appropriate or necessary, supported financially those groups, both in and out of government best qualified to work on various aspects of the problem.

For instance, the best evidence as to the ultimate resting place of global fallout is to collect and to analyze soil for strontium 90 on a global basis. This has been done by the Department of Agriculture with analytical support by the Commission. The Commission made arrangements with scientists in Australia, New Zealand, and other countries to participate in this program.

Scientists of the Lamont Geological Observatory, Columbia University, have for several years assumed responsibility for our national and world-wide human bone studies. They also have made studies in soil uptake of strontium 90 and collected and analyzed a variety of foods from many places in the United States and abroad. The food collection program has cooperation from the Interdepartmental Committee on Nutrition which assisted in procuring food from South America and other areas. Recently with Atomic Energy Commission support the United States Public Health Service has undertaken a regional study of strontium 90 in humans in the vicinity of the Nevada Test Site.

One of the critical parts of the program has been the analytical work. The Commission's Health and Safety Laboratory has been responsible for developing methods and procedures for analyzing strontium 90 in a variety of materials, soil, grass, water, air samples, etc. It has worked with the several contract laboratories on methods, standardization of procedures, and most important and at times most discouraging of all, the matter of quality control which has plagued those who have worked at the low levels dealt with in fallout studies.

The program of fallout sampling and monitoring supported by the Commission during the fiscal year 1960 will include the following work:

Development of Stratospheric and Ground Level Sampling Devices by Armour Research Foundation, Atlantic Research Corp., Del Electronics Corp., General Mills, Inc., Georgia Institute of Technology, and Meteorology Research, Inc.

Stratospheric and Surface Air Sampling and Analysis by the Air Force, Public Health Service, AEC Health and Safety Laboratory, and Naval Research Laboratory.

Measurement of Fallout Deposition on Earth's Surface and Measurement of Fallout in Plants, Animals and Man by the Department of Agriculture, Air Force, Air Research and Development Command, University of Arkansas, University of California at Los Angeles, Columbia University Lamont Geological Observatory, General Electric Co. at Hanford, National Institutes of Health and Bureau of State Services, Department of Health, Education and Welfare, AEC Health and Safety Laboratory, Geological Survey, University of Michigan, Mount Washington Observatory, University of Washington Laboratory of Radiation Biology, and Woods Hole Oceanographic Institute.

Compilation and Meteorological Interpretation of Fallout Data by U.S. Weather Bureau, Nuclear Science and Engineering Corp., and Isotopes, Inc.

This program has been primarily a scientific research program with the purpose of understanding the factors that influence the patterns and rates of fallout onto the earth's surface whether the debris is tropospheric or stratospheric in origin and whether the fallout material originates near the equator or at some other latitude. What has been demanded is four dimensional sampling, in two dimensions over the surface of the earth, a third dimension out to 100,000 feet or more in the earth's atmosphere and a fourth in time.

As long as radiochemical analysis for strontium 90 remains as expensive and difficult as it is today, enough sampling and analysis to answer everybody's questions will be impossible. Each year several million samples of milk are analyzed for bacterial count. To do the same for fallout would cost several hundred million dollars a year. However, an occasional item in the diet that is relatively high in strontium 90 carries none of the consequences of a batch of milk contaminated with hemolytic streptococci or tubercle or diphtheria bacilli. It is the average strontium 90 intake over the year which will be reflected in the bone, not peak values nor lowest values. With all the milk sampling locations averaging well under 30 micromicrocuries of strontium 90 per liter to date it is unlikely that in the United States the average level of radiation to the bone from strontium 90 from weapons tests detonated to date will equal the sea level "natural background" exposure.

The Commission's experimental and laboratory research in biology and medicine related to the problem of fallout falls naturally into two major categories.

First is the movement of fallout into and in the food chain and water supplies, once it has been deposited on the earth's surface, and, in addition, the matter of absorption by man from food, water or air and the deposition and ultimate fate of different isotopes in the human body. Table VII—Sampling Systems Related to Radioactive Fallout gives details.

Second is the work aimed at determining the effects of ionizing radiation on the human body and on human germ cells in order to gain a more precise knowledge of the hazards of fallout, some of which is described later in this section.

The Commission-supported work on soil chemistry and movement of strontium 90, cesium 137 and other nuclides from soils and plants into the food chain includes 25 projects in the fiscal year that will end June 30, 1960 (see Appendix 15). Additional projects are under way at Commission installations.

Some results of Commission-sponsored and United Kingdom studies of soil and pasture have been cited earlier, the lack of important discrimination by plants against strontium 90, the importance of direct uptake that bypass the soil, the limited value of liming, or similarly treating acid soils, to reduce uptake. Other facts brought out by the studies include:

a) The levels of strontium 90 fluctuate month to month, season to season, but soil levels and bone levels have risen slowly and steadily.

b) There is evidence for some slow fixation of strontium 90 in some soils.

c) Strontium 90 is slowly moving downward in unplowed soil.

In the Commission's research program in molecular biology, fundamental work is aimed at unravelling the mechanisms and the several steps involved in production of radiation injury at the molecular level. It may short cut the direct approach to the problem involving hundreds of thousands of laboratory animals, and provide leads to methods for forestalling or correcting radiation injury.

Summaries of Research Results

A few examples of work aimed at measuring the biological effects of low-level radiation are described in the following pages. Other studies related to the fallout problem are covered in the preceding portion of this report devoted to progress in research in the life sciences.

Long-term studies in animals. The Radiobiology Laboratory of the University of Utah under contract with the Commission has been carrying out long-term studies on dogs to determine the distribution, excretion rate and pathological effects of chronic dosages with five radioisotopes of interest to the Commission. These studies have been under way for 7 years, and are to continue until the experimental animals die. Some 300 young beagle hounds have received single injections of radioactive strontium, radium, plutonium, radiothorium, or mesothorium. Physical examinations are carried out periodically to assess biological damage. Of equal importance are determinations of the body burdens of isotopes using a whole body counter designed especially for dogs. Without this instrument, a much greater number of dogs would have had to be used to establish rates of elimination. Upon death, each dog will be given extensive pathological, radiochemical, and autoradiographic studies.

A project at the University of California at Davis, Calif., began in July 1951 with the objective of ascertaining the effects of whole-body X-irradiation on work capacity and longevity in beagle hounds. At present, the average age of the dogs is 6 years and approximately 10–12 percent of the colony has died. Although no major differences in the time of death is yet evident among the three groups—one a control group, two others receiving exposures of 100*r* and 300*r*—the irradiated animals are showing a higher incidence of neoplastic diseases, principally as adenocarcinomas of the mammary gland. One-half the animals in each group have been bred, but this does not seem to influence markedly the probability of death from mammary tumor. The results of breeding of the irradiated dogs are essentially normal.

The death rate in the colony is rising and the next several years should produce information as to the effects of the initial radiation exposure on life expectancy and cause of death, as well as on detrimental effects that might arise from a combination of irradiation exposure and reproductive activity.

At the Veterinary School of the University of California at Davis, Calif., a long-term project is being developed using dogs to determine the relation between effects of radium 226 and strontium 90. The figures are known for radium 226 in man, and ratios obtained from this experiment can be extrapolated back to man.

Strontium 90 will be fed at five systematic dose levels to pregnant and nursing females so that the pups, on weaning, will have specific levels of strontium 90 in their bones. They then will receive similar graded amounts of strontium 90 in their food until they reach 18 months of age. These animals then will be observed until their deaths. The strontium 90 series will be paralleled by a similarly treated group of dogs receiving radium 226.

To care individually for some 450 radioactively contaminated animals, it was necessary to devise a sound decontamination system for the waste, to design easily decontaminated metabolism cages, and to build holding pens adapted to the normal needs of the animal. Live trial-runs of all procedures are being carried out. It is known already that the highest dose level of strontium 90, some 125 times the maximum permissible concentration, produces leukemia in the dog, together with serious pathological changes in bone.

Dietary studies in animals. The assimilation of fission products in man and animals is known to be closely dependent on such dietary factors as nutrition, vitamin and hormone action and on such physiological factors as growth, gestation, and lactation. To obtain addi-

tional data concerning these factors, New York State Veterinary College, Cornell University, is investigating fission product metabolism and response in laboratory and domestic animals, and consequent movement of these nuclides through the food-chain to man. Factors governing relationships between dietary intake, retention and elimination of radioisotopes of strontium, cesium, iodine and barium have been studied. Experiments using radioactive isotopes of strontium and calcium have revealed such findings as a strontium-calcium ratio in milk of 0.09 to 0.16 to that present in the ration being consumed by the animal. It also has been shown that the stable calcium level in blood plasma may be elevated from a normal level of about 12 milligrams percent to about 22 milligrams percent without show of outward distress by the animal.

Strontium 85 studies in man. Since the long half-life of strontium 90 precludes its use in clinical investigations with volunteers, radioactive strontium 85, with a relatively short half-life of 65 days, is being used extensively in studies of the metabolism of radiostrontium in man.

Studies of the metabolism of strontium indicate a preferential urinary excretion, higher renal clearance, and lower body retention of strontium 85 than of calcium 45 following an intravenous injection of the tracer isotopes; the average ratio of Sr^{85} to Ca^{45} is 2.8. With oral administration, it was found that strontium 85 was poorly absorbed from the gastrointestinal tract when compared to calcium 45, approximately 3 times more calcium than strontium being absorbed. Thus, due to the poor gastrointestinal absorption of strontium and to the preferential urinary excretion of the absorbed radiostrontium, the body burden of strontium 85 is considerably lower than that of calcium 45.

Another study indicated that at 30 days 50 percent of the administered dose of strontium 85 remains in the body and that subjects with skeletal abnormalities such as multiple myeloma, hyperparathyroidism, or osteoporosis tend to retain strontium with great avidity, in one case in the face of great calcium loss.

These results in man confirm the earlier studies in animals. The reasons for these discrimination differences are as yet unknown.

Radioactive decontamination of milk. Although not necessary under current conditions, removal of radioactive contamination from foods was being studied to provide basic information against possible emergencies. A series of laboratory scale studies carried out at the University of Tennessee-AEC Agricultural Research Laboratory, Oak Ridge, Tenn., demonstrated that up to 94 percent of contained stron-

tium can be removed from milk without appreciable alteration of the milk. The most useful technique involved separating the milk (the cream fraction contains very little strontium) and treating the skim milk with the calcium form of a cation exchange resin. Studies in Canada also have indicated the feasibility of removing both strontium and cesium from milk, while work in the United Kingdom demonstrated removal of strontium and iodine from milk.

The Commission has joined in a cooperative program with the U.S. Department of Agriculture and the U.S. Public Health Service to examine the feasibility of removing strontium from milk on a pilot plant scale. These studies will be carried out at the United States Department of Agriculture, Agricultural Research Center at Beltsville, Md.

Iodine 131 uptake in animals and man. Research conducted at the University of Tennessee School of Medicine during the past several years has used selective uptake of iodine by the thyroid to assess the contamination of the environment by studies in man, sheep, cattle, and swine. Samples for assay have been collected from the United States, Canada, Australia, Japan, Republic of China, the United Kingdom, and the Federal Republic of Germany. Assay data are available from January 1956 for most of the specimen classes. During October and November 1959, increases in uptake of iodine 131 in the thyroids of cattle and sheep have been noted both in the United States and the United Kingdom.

Estimates have been made based on iodine concentrations in milk which suggest that a few children in the United States may have received 1.8 rads to the thyroid gland.

Fallout Information for the Public

In order to keep the Congress and the public currently and fully informed on the subject of fallout and its possible consequences, the Commission publishes new facts as rapidly as possible. Some information that bears directly on security and national safety is held secret. The Commission does not carry exclusively the responsibility for decisions on what must be kept secret. Other agencies, including the Department of State, the Department of Defense, and the Central Intelligence Agency are directly concerned.

The Commission issued the Health and Safety Laboratory Report No. 42 in October 1958—a 359-page summary report entitled "Environmental Contamination from Weapon Tests." Subsequent quarterly technical reports on world-wide fallout have been distributed

to news media and made available for sale through the Office of Technical Services, U.S. Department of Commerce. Many other reports originating in various Commission laboratories (examples are UCRL-8083, "Estimation of Turnover Equation of Strontium-90 for Human Bones," by P. K. Kuroda; and BNL-496 "The Distribution of Fallout Activity in Rainfall at BNL, June–September 1957," by F. P. Cowan and J. Steimers) also are made available for sale.

From time to time the Commission issues special fallout reports through the Government Printing Office (examples are "Some Effects of Ionizing Radiation on Human Beings," 1956, by E. O. Cronkite, V. P. Bond and C. L. Dunham; and "Radioactive Contamination of Certain Areas in the Pacific Ocean from Nuclear Tests," 1957, by G. M. Dunning). In 14 Semiannual Reports to Congress, sections on fallout problems were included, for example, in the Fourteenth, Sixteenth, Nineteenth, Twenty-second and Twenty-third Semiannual Reports. Scientific papers prepared by biophysical, biological and medical scientists supported by the Commission appear in technical journals throughout the world, as have papers specifically on world-wide fallout prepared by members and staff of the Commission.

The United States has been the principal source of fallout information provided to the United Nations Scientific Committee, largely because of the extensive data made available by the Commission. In addition, the Commission issues regular quarterly public information summaries on fallout, the first being released September 8 and October 9, 1959.

The Commission is continuing to declassify fallout information which might concern the public health and welfare, and making the data available as soon as possible after its collection. A concerted review was made throughout the Commission to find classified reports in this area and a special declassification team was organized. A total of 2,160 documents were identified as containing some information relating to the radioactive content of the atmosphere in fallout. Some 501 of these had been previously released or duplicated in other reports. Of the remaining 1,659 reports (1,033 unclassified and 626 classified) 84 unclassified reports were found to contain information useful to the public for evaluation of radioactive hazards. Of the 626 classified reports in this group, 79 were declassified, most without deletions, and prepared for distribution to the public by sale through the Office of Technical Services, Department of Commerce. Previously declassified and unclassified documents are available in the same way, and all will be summarized in the Commission's regular publication, *Nuclear Science Abstracts*.

The published reports of the 1959 Hearings on Fallout by the

Special Subcommittee on Radiation of the Joint Committee on Atomic Energy, to which the Commission submitted a large number of summaries and reviews will provide a broad survey of up-to-date knowledge. Individual papers submitted for the Hearings have been published separately by the Commission and made available to the public.[46]

A scientific meeting of major importance, the University of Minnesota Symposium on Radioisotopes in the Biosphere, was held in October under joint sponsorship of the Commission, the National Science Foundation and the Agricultural Research Services, U.S. Department of Agriculture. Held in Minneapolis the symposium drew approximately 150 scientists from the United States, Canada, Norway, Sweden, the United Kingdom, New Zealand and Australia. The printed proceedings of the symposium will be given wide distribution.

Health and Safety

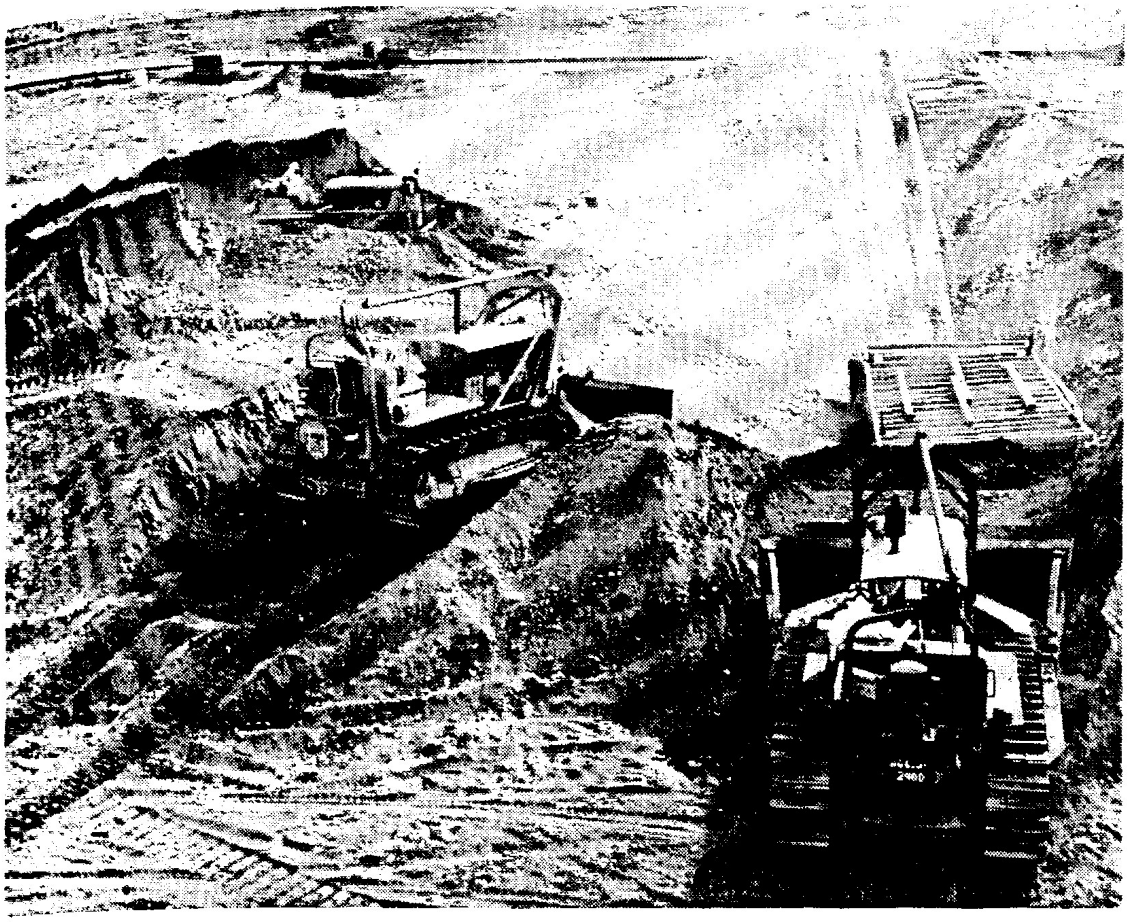
As a means of centralizing its responsibilities in the field of radiation protection, the Commission, on September 12, 1959, established within its headquarters an Office of Health and Safety. The new organization was assigned primary responsibility, in cooperation with other Commission offices and divisions, for: (*a*) developing and recommending health standards for protection of the public from atomic energy-induced radiation; (*b*) serving as a focal point for Commission relationships with State Governments in the area of radiation protection; and (*c*) developing policies and recommending standards for protection of Commission, and contractor, personnel from nonnuclear as well as radiation hazards.

Actions Under New Law

Cooperation With States

Public Law 86–373, effective September 23, 1959, further amended the Atomic Energy Act of 1954 by adding a new section 274, "Coop-

[46] Available through the Office of Technical Services, U.S. Department of Commerce, Washington 25, D.C. One of the important publications is TID–5550, "Radioactive Fallout—A Two-Year Summary" by C. L. Dunham, M.D., Director, Division of Biology and Medicine, AEC. Price $1.25. A "Summary-Analysis of Hearings," prepared by the Commission and Joint Committee on Atomic Energy staffs is available from the Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C.



Deep burial. Bulldozers, working from behind mounds of earth, backfill a deep pit into which a box containing highly-contaminated obsolete equipment has been snaked off a railroad car (note skid marks in upper right of photo). Since radiation normally travels in straight lines, these Hanford bulldozer operators are protected by the mounds of earth they push into the "grave." Protective masks prevent inhalation of possibly-contaminated dust.

and purified before entering the reactors, traces of minerals still left in the cooling, or eroded from the process tubes, water are made radioactive by the bombardment of neutrons. Small quantities of fission products also are present from the natural uranium in the water, and from occasional ruptures of fuel elements. Close control of water quality by treatment plants holds down the amount of resulting radioactivity, *i.e.*, removal of impurities which would be activated by neutrons results in less radioactivity in the coolant stream. Some foreign materials inevitably deposit on the surfaces of the process tubes and fuel elements to form a film, which is periodically removed by "purging" with mild abrasives.

Prior to release to the Columbia River, the effluent is retained from one to three hours in large basins or tanks. During this time, radioactive decay reduces the gross radioactivity of the water by 50 to 70 percent. The retention basins are monitored, and effluent which has an unusually high radioactive content because of occasional ruptures of fuel elements and purges is discharged to trenches where it seeps